Global monitoring

MODIS 250 meter surface reflectance composite

Hansen, M.C., Potapov, P.V., and Stehman, S.V., 2010, Quantification of global forest cover loss, Proceedings of the National Academy of Sciences, vol. 107, no. 19, pp. 8650-8655.

MODIS time-series imagery were processed to estimate year 2000 percent tree cover and 2000 to 2010 forest cover loss.

Remote sensing-derived change products such as this quantify the biophysical extent and loss of forest cover. While absent of land use considerations, they improve the consistency of forest area and change estimates across space and through time.
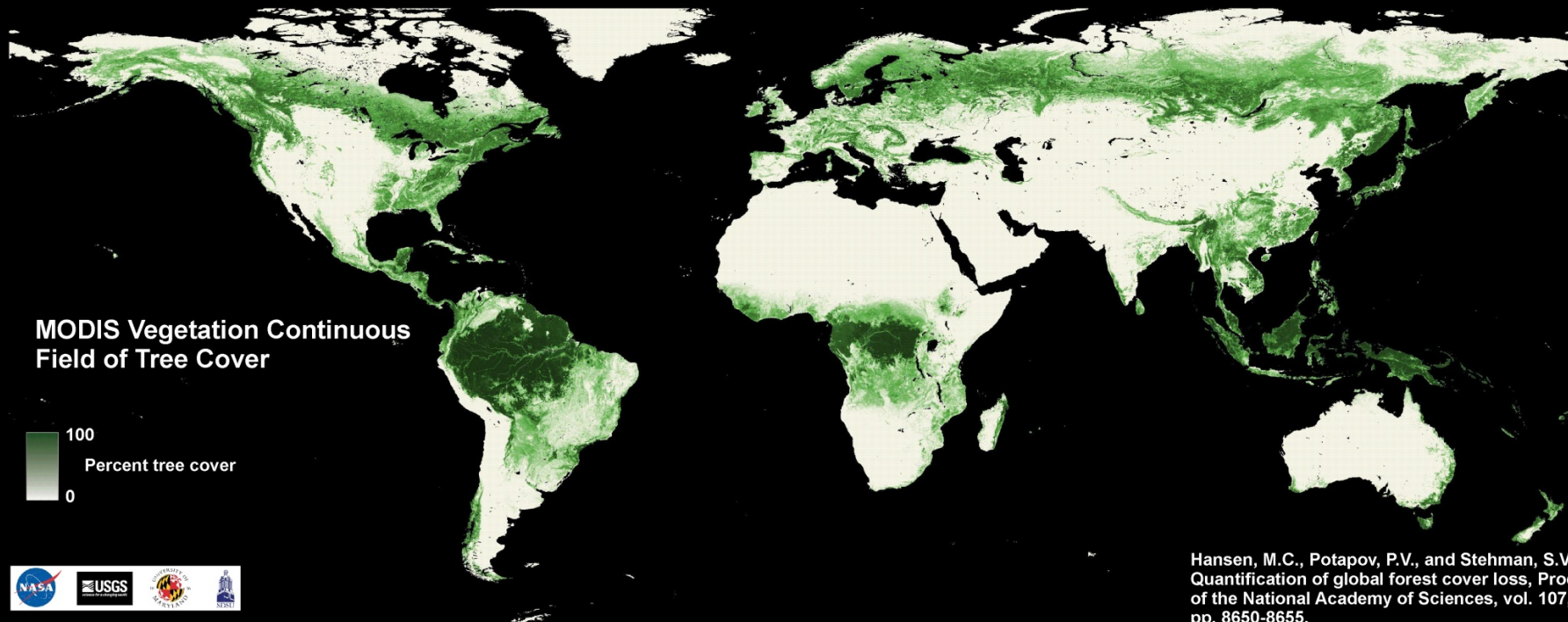
Results illustrate a pervasive global forest cover loss dynamic with a reduction in gross forest cover loss in 2005 to 2010 compared to 2000 to 2005, largely attributable to a slowing of deforestation in Brazil.

While this depiction of change does not provide attribution of the drivers of forest cover loss, principal causes include clearing for agriculture, such as soybean expansion in South America, palm estates and timber plantations in Insular Southeast Asia, logging and disease in North America, and fire across the boreal biome.

The Americas account for more than half of all global gross forest cover loss for both epochs with a number of drivers contributing including logging, fire, disease and storm damage.

Africa has the lowest proportional change due to a lack of large scale agro-industrial investment. Most forest conversion in Africa is due to small-scale subsistence farming practices.

Global monitoring

MODIS Vegetation Continuous Field of Tree Cover

100
Percent tree cover
0

Hansen, M.C., Potapov, P.V., and Stehman, S.V., 2010, Quantification of global forest cover loss, Proceedings of the National Academy of Sciences, vol. 107, no. 19, pp. 8650-8655.

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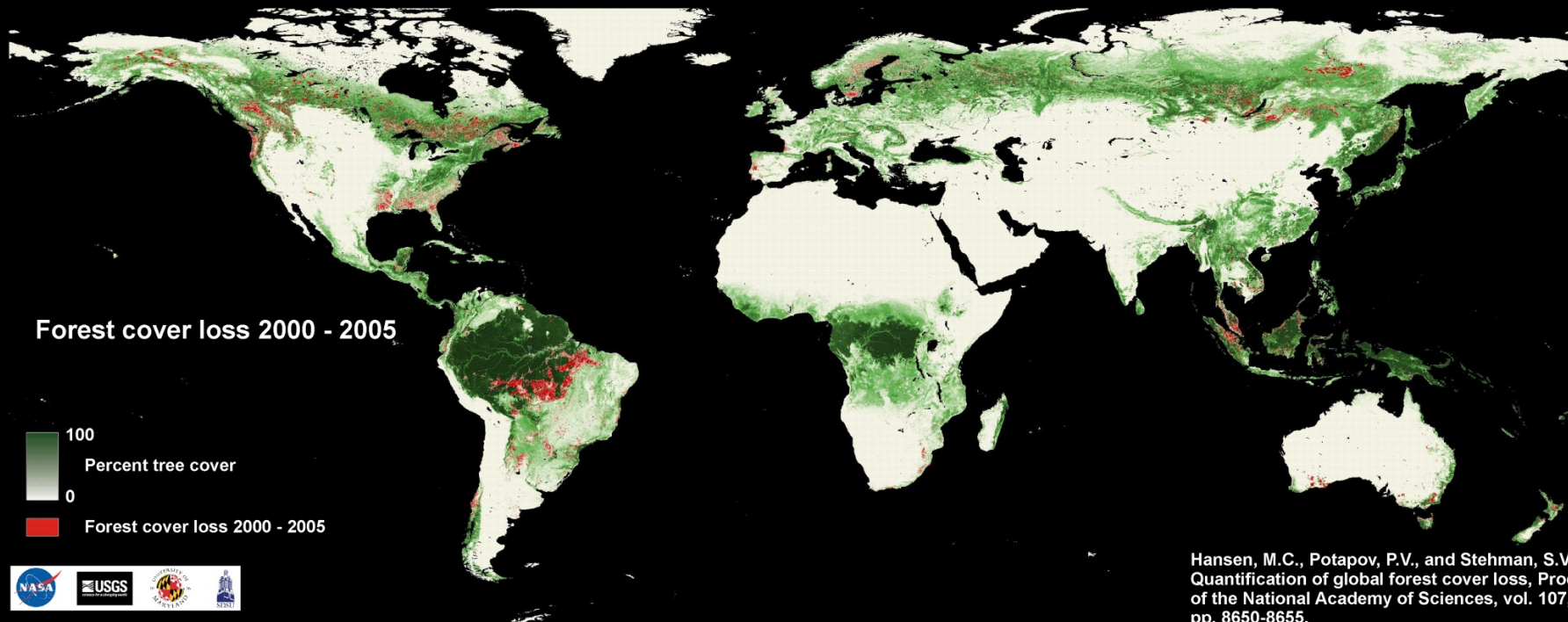
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Global monitoring

Forest cover loss 2000 - 2005

100

Percent tree cover

0

Forest cover loss 2000 - 2005

Hansen, M.C., Potapov, P.V., and Stehman, S.V., 2010, Quantification of global forest cover loss, Proceedings of the National Academy of Sciences, vol. 107, no. 19, pp. 8650-8655.

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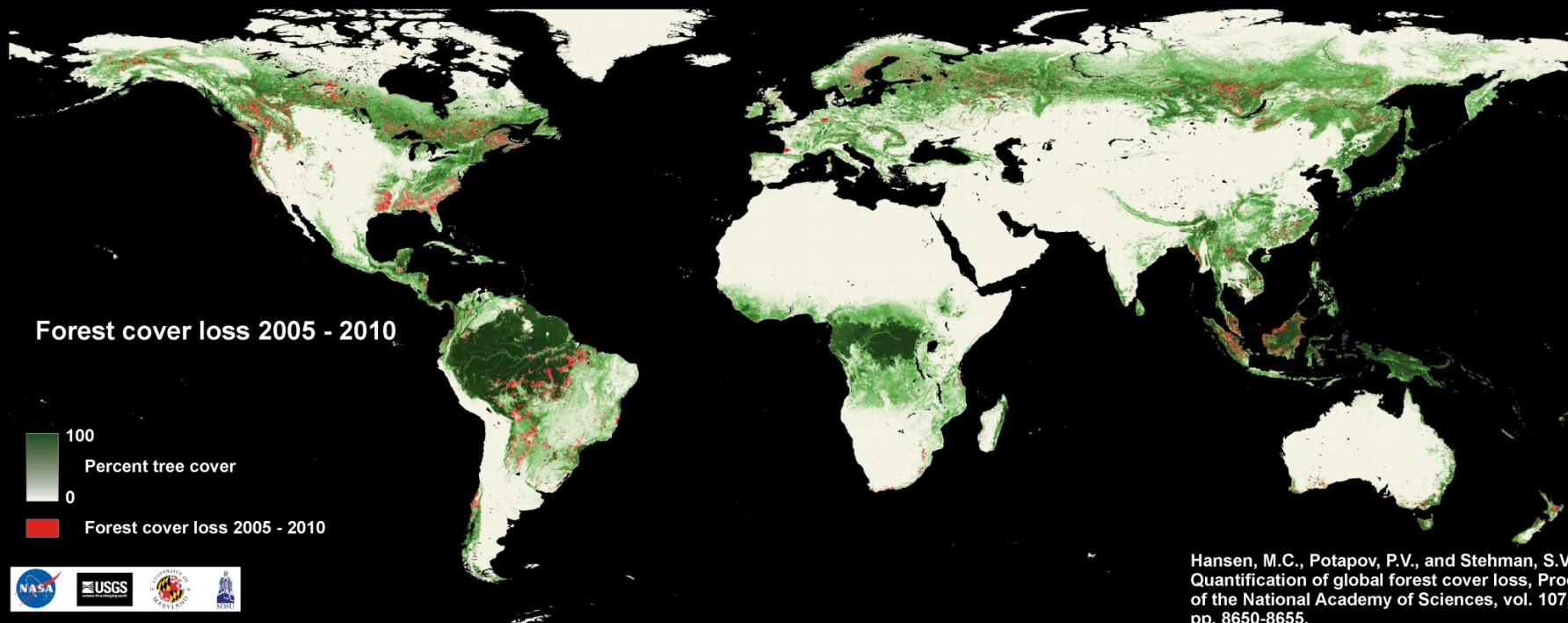
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Global monitoring

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Global monitoring

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Percent tree cover
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Forest cover loss 2005 - 2010

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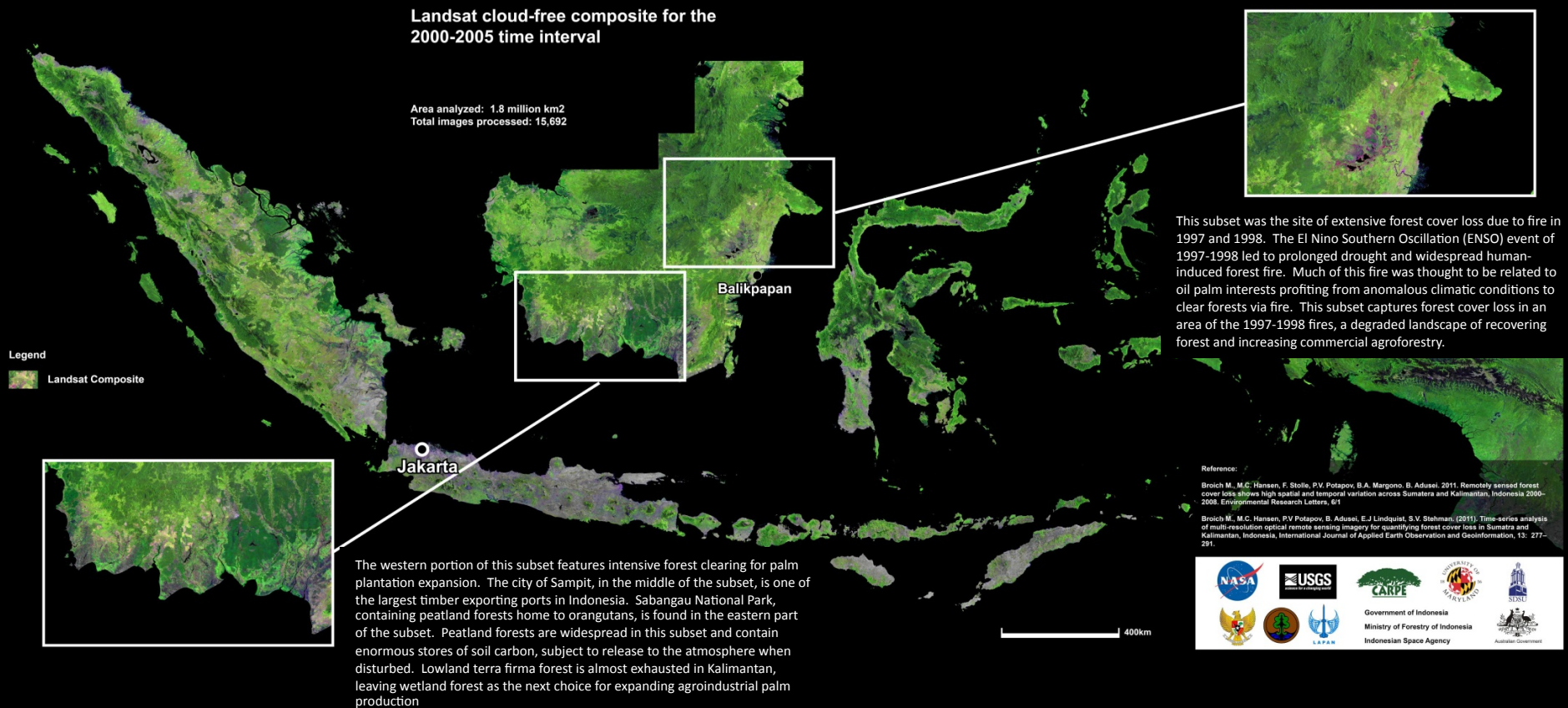
Preliminary findings:

⬇ Humid tropics – dramatic decrease in Brazilian Amazon forest cover loss, increased loss in Indonesia and Malaysia

⬆ Dry tropics – increased forest cover loss in Argentina, Paraguay, Bolivia and southern Africa

⬇ Boreal – decrease in North American forest loss, increased loss in Russia

↔ Temperate – no significant change in magnitude of forest cover loss

Indonesia forest monitoring

Landsat cloud-free composite for the 2000-2005 time interval

Area analyzed: 1.8 million km2
Total images processed: 15,692

Balikpapan

Jakarta

Legend

Landsat Composite

This subset was the site of extensive forest cover loss due to fire in 1997 and 1998. The El Nino Southern Oscillation (ENSO) event of 1997-1998 led to prolonged drought and widespread human-induced forest fire. Much of this fire was thought to be related to oil palm interests profiting from anomalous climatic conditions to clear forests via fire. This subset captures forest cover loss in an area of the 1997-1998 fires, a degraded landscape of recovering forest and increasing commercial agroforestry.

Reference:

Broich M., M.C. Hansen, F. Stolle, P.V. Potapov, B.A. Margono. B. Adusei. 2011. Remotely sensed forest cover loss shows high spatial and temporal variation across Sumatera and Kalimantan, Indonesia 2000–2008. Environmental Research Letters, 6/1

Broich M., M.C. Hansen, P.V Potapov, B. Adusei, E.J Lindquist, S.V. Stehman. (2011). Time-series analysis of multi-resolution optical remote sensing imagery for quantifying forest cover loss in Sumatra and Kalimantan, Indonesia, International Journal of Applied Earth Observation and Geoinformation, 13: 277–291.

Government of Indonesia
Ministry of Forestry of Indonesia
Indonesian Space Agency

The western portion of this subset features intensive forest clearing for palm plantation expansion. The city of Sampit, in the middle of the subset, is one of the largest timber exporting ports in Indonesia. Sabangau National Park, containing peatland forests home to orangutans, is found in the eastern part of the subset. Peatland forests are widespread in this subset and contain enormous stores of soil carbon, subject to release to the atmosphere when disturbed. Lowland terra firma forest is almost exhausted in Kalimantan, leaving wetland forest as the next choice for expanding agroindustrial palm production

400km

Application of the Landsat processing and characterization method for Indonesia is supported by the Indonesia-Australia Forest Carbon Partnership (IAFCP) in collaboration with the Indonesian Space Agency, the Indonesian Ministry of Forestry and the Indonesian National Coordinating Agency for Surveys and Mapping. Timely forest cover extent and change data are required for the Indonesian National Carbon Accounting System (INCAS) whose objectives include the provision of a comprehensive and credible accounting of Indonesia's land-based carbon emissions. Methods development was supported by NASA's Land Cover and Land Use Change program and USAID with additional support from USGS.
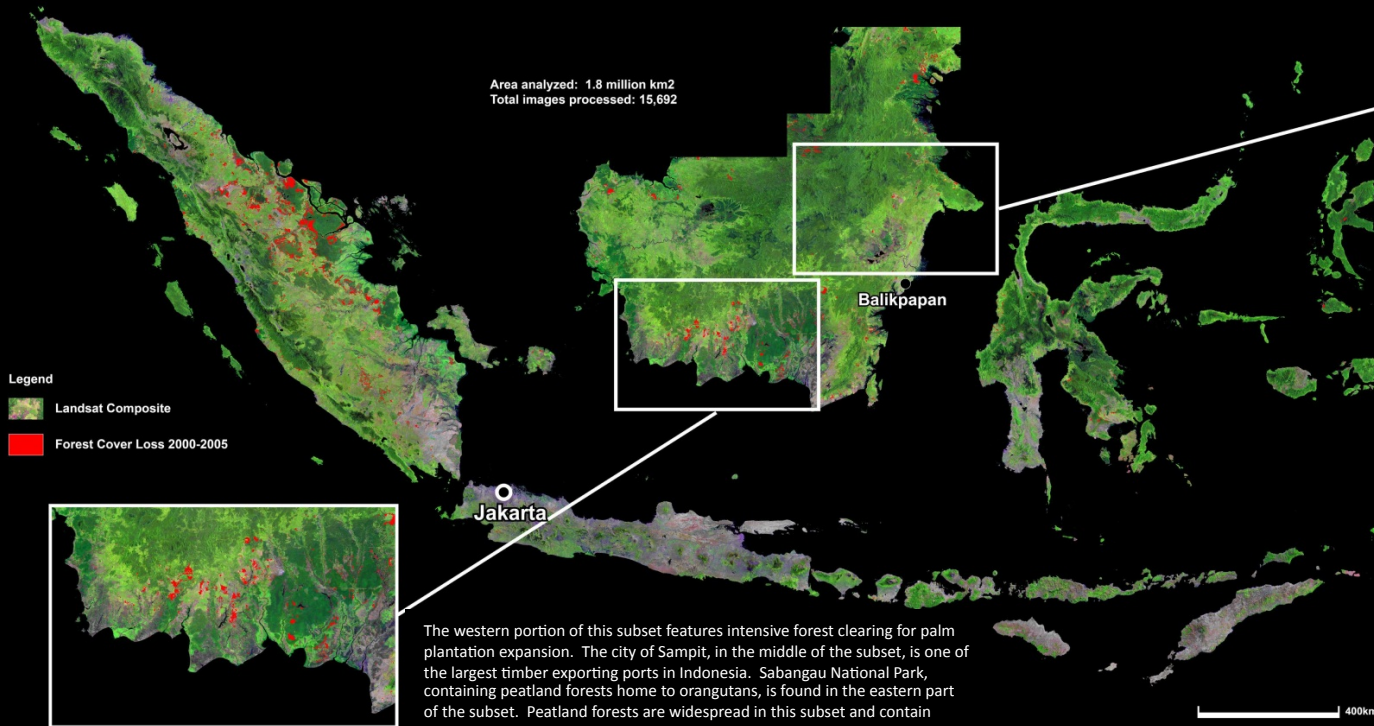
An exhaustive mining of the Landsat ETM+ archive was performed to map forest cover extent and loss for Indonesia from 2000 to 2010. All Landsat imagery were processed to radiometrically normalized reflectance values and subsequently used to produce time-sequential image composites. The method relied on MODIS-derived surface reflectance data as a normalization target for Landsat image processing. Supervised learning algorithms were then applied to the time-series data sets to quantify both forest cover extent and loss.

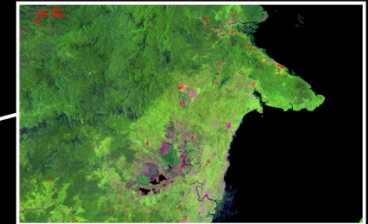# Indonesia forest monitoring

Forest Cover Loss 2000-2005

Area analyzed: 1.8 million km2
Total images processed: 15,692

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Legend

Landsat Composite

Forest Cover Loss 2000-2005

Jakarta

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Broich M., M.C. Hansen, F. Stolle, P.V. Potapov, B.A. Margono. B. Adusei. 2011. Remotely sensed forest cover loss shows high spatial and temporal variation across Sumatera and Kalimantan, Indonesia 2000–2008. Environmental Research Letters, 6/1
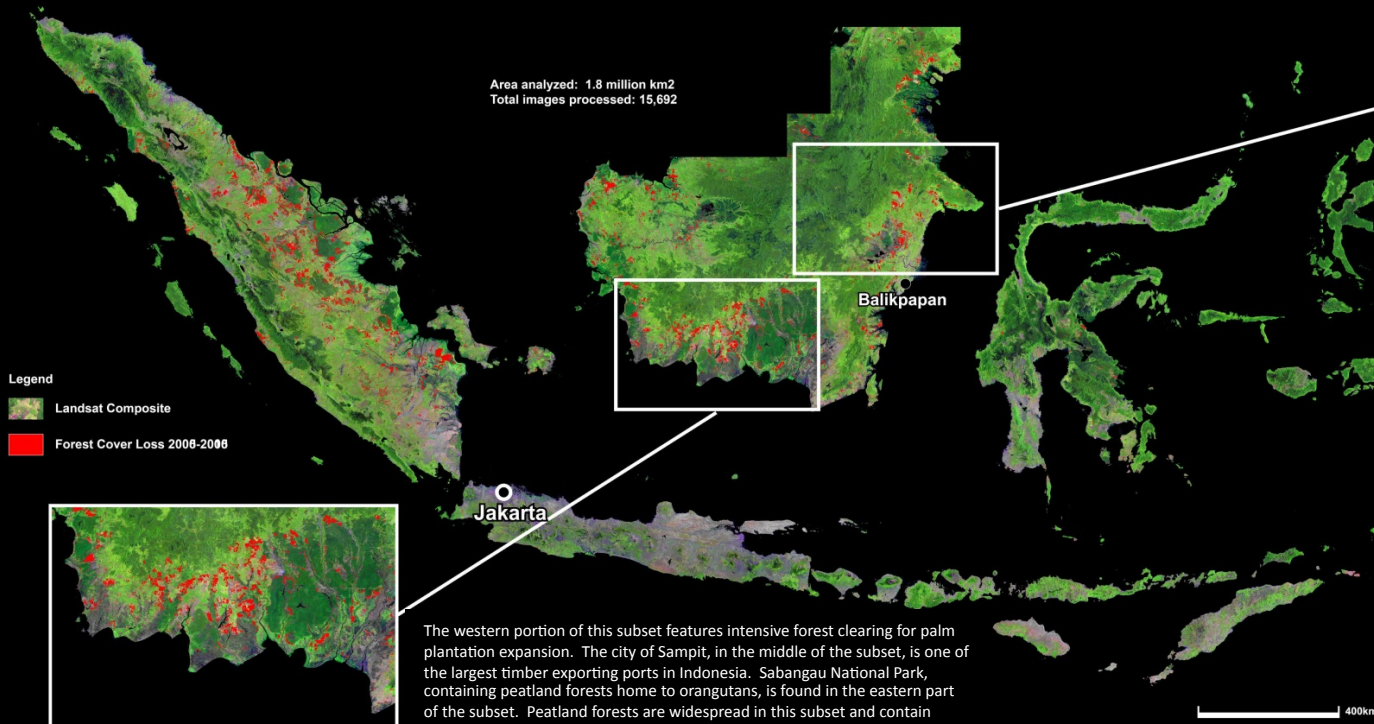
Broich M., M.C. Hansen, P.V Potapov, B. Adusei, E.J Lindquist, S.V. Stehman. (2011). Time-series analysis of multi-resolution optical remote sensing imagery for quantifying forest cover loss in Sumatra and Kalimantan, Indonesia, International Journal of Applied Earth Observation and Geoinformation, 13: 277–291.

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400km

Government of Indonesia
Ministry of Forestry of Indonesia
Indonesian Space Agency

Indonesia forest monitoring

Forest Cover Loss 2005-2010

Area analyzed: 1.8 million km2
Total images processed: 15,692

Balikpapan

Jakarta

Legend

Landsat Composite

Forest Cover Loss 2008-2008

This subset was the site of extensive forest cover loss due to fire in 1997 and 1998. The El Nino Southern Oscillation (ENSO) event of 1997-1998 led to prolonged drought and widespread human-induced forest fire. Much of this fire was thought to be related to oil palm interests profiting from anomalous climatic conditions to clear forests via fire. This subset captures forest cover loss in an area of the 1997-1998 fires, a degraded landscape of recovering forest and increasing commercial agroforestry.

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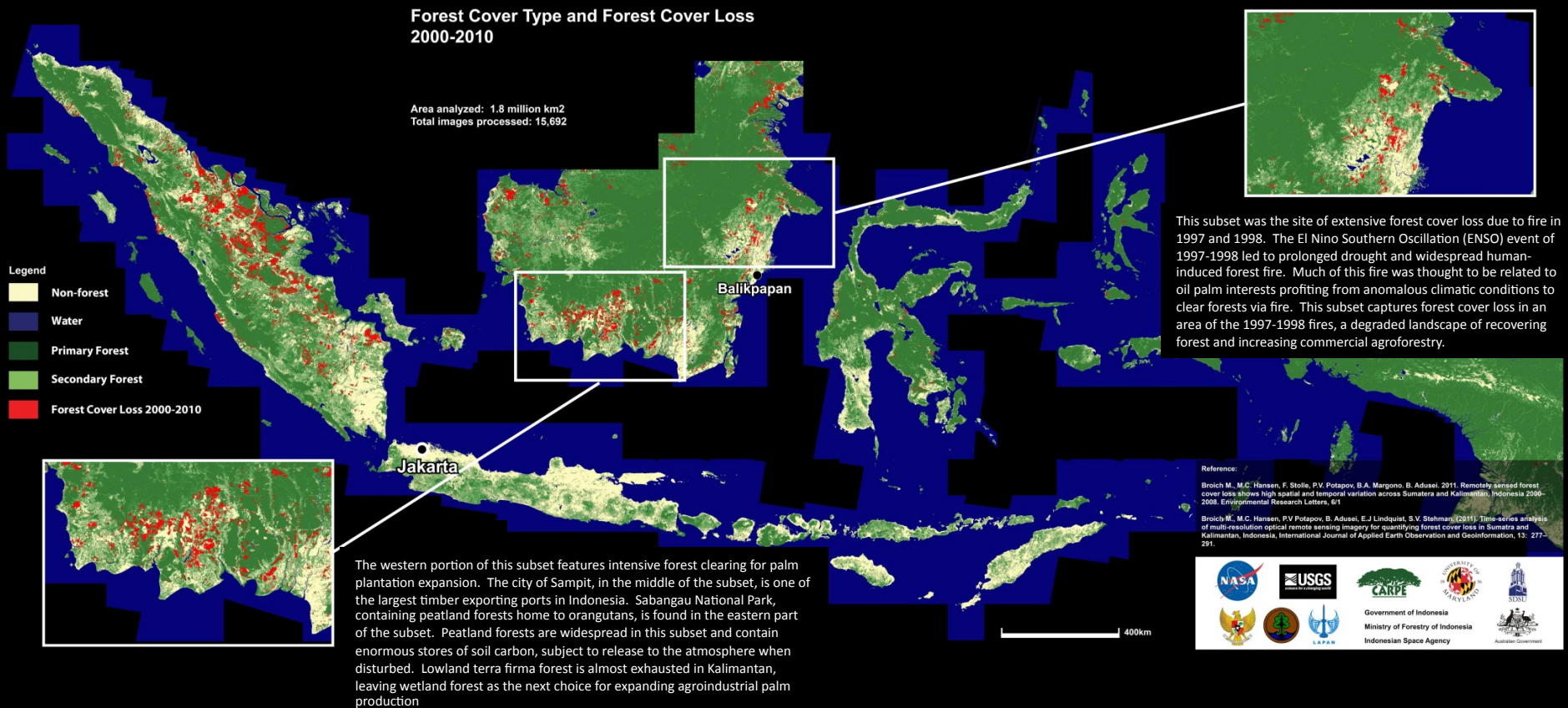
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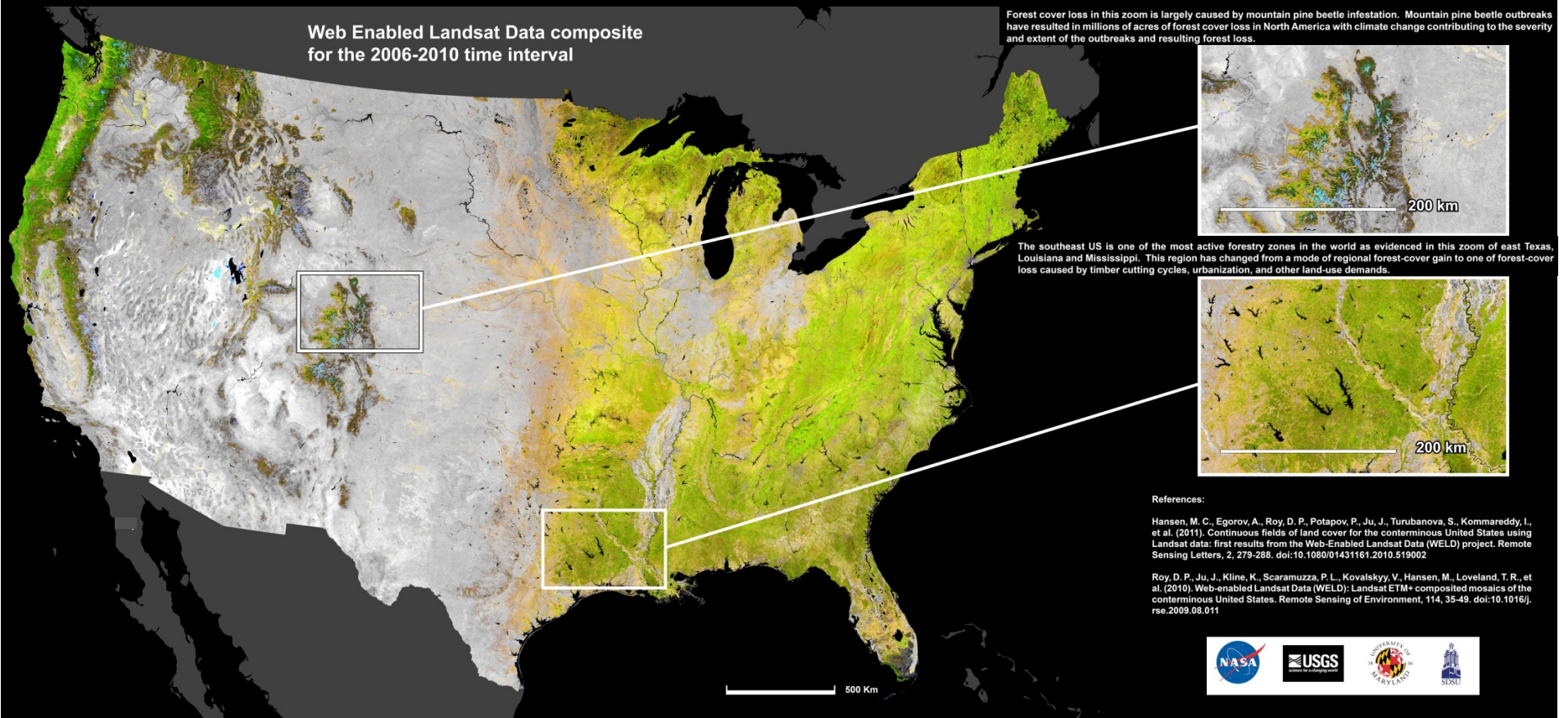
400km

Government of Indonesia
Ministry of Forestry of Indonesia
Indonesian Space Agency

Indonesia forest monitoring

**Forest Cover Type and Forest Cover Loss
2000-2010**

Area analyzed: 1.8 million km2
Total images processed: 15,692

Legend

- Non-forest
- Water
- Primary Forest
- Secondary Forest
- Forest Cover Loss 2000-2010

Balikpapan

Jakarta

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400km

NASA   USGS   CARPE   UNIVERSITY OF MARYLAND   SDSU

Government of Indonesia
Ministry of Forestry of Indonesia
Indonesian Space Agency   Australian Government

- Total gross forest cover loss was estimated to be 92.1 thousand km2 from 2000 to 2010.
- Forest cover loss increased by 53% from the 2000-2005 to 2005-2010 interval.
- The proportion of forest cover loss within primary forests versus other forest types was nearly equal, with 46% of clearing occurring within primary forests, and 54% within timber plantations, palm estates and secondary regrowth.
- The majority of mapped forest cover loss (80%) occurred in land allocation zones that permit permanent or temporary clearing, while 20% occurred where clearing is either prohibited or restricted.   Effective enforcement of existing biodiversity conservation forest, watershed protection, and limited production forest land use designations could significantly reduce forest cover loss.
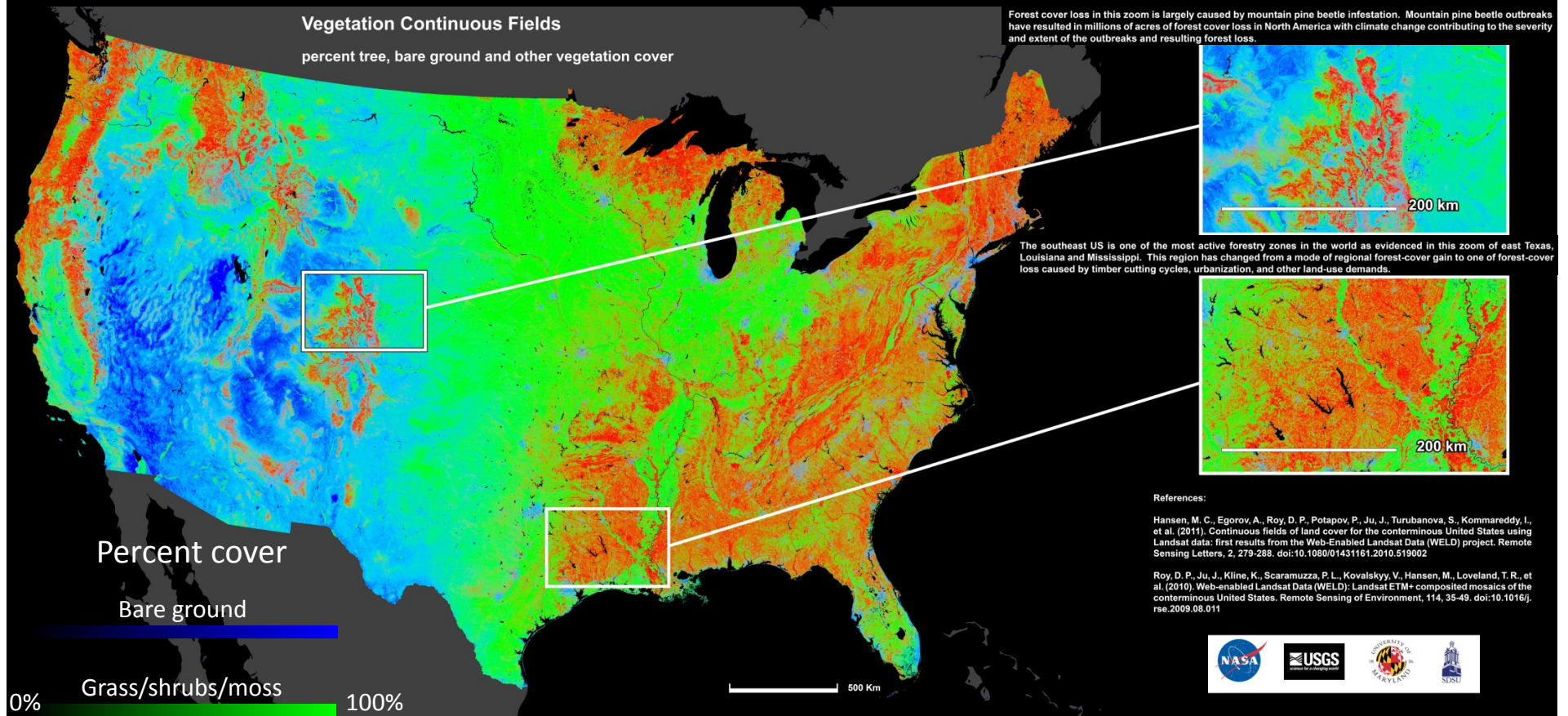
United States land cover monitoring

Web Enabled Landsat Data composite for the 2006-2010 time interval

Forest cover loss in this zoom is largely caused by mountain pine beetle infestation. Mountain pine beetle outbreaks have resulted in millions of acres of forest cover loss in North America with climate change contributing to the severity and extent of the outbreaks and resulting forest loss.

200 km

The southeast US is one of the most active forestry zones in the world as evidenced in this zoom of east Texas, Louisiana and Mississippi. This region has changed from a mode of regional forest-cover gain to one of forest-cover loss caused by timber cutting cycles, urbanization, and other land-use demands.

200 km

References:

Hansen, M. C., Egorov, A., Roy, D. P., Potapov, P., Ju, J., Turubanova, S., Kommareddy, I., et al. (2011). Continuous fields of land cover for the conterminous United States using Landsat data: first results from the Web-Enabled Landsat Data (WELD) project. Remote Sensing Letters, 2, 279-288. doi:10.1080/01431161.2010.519002

Roy, D. P., Ju, J., Kline, K., Scaramuzza, P. L., Kovalskyy, V., Hansen, M., Loveland, T. R., et al. (2010). Web-enabled Landsat Data (WELD): Landsat ETM+ composited mosaics of the conterminous United States. Remote Sensing of Environment, 114, 35-49. doi:10.1016/j.rse.2009.08.011

500 Km

Vegetation Continuous Field (VCF) layers of 30 m percent tree cover, bare ground, other vegetation and probability of water were derived for the conterminous United States (CONUS) using Landsat 7 Enhanced Thematic Mapper Plus (ETM+) data sets from the Web-Enabled Landsat Data (WELD) project.

Turnkey approaches to land cover mapping were enabled due to the systematic WELD Landsat processing, including conversion of digital numbers to calibrated top of atmosphere reflectance and brightness temperature, cloud masking, reprojection into a continental map projection and temporal compositing.

United States land cover monitoring

Vegetation Continuous Fields

percent tree, bare ground and other vegetation cover

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Percent cover

Bare ground

Grass/shrubs/moss

0%   100%

Trees

500 Km

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United States land cover monitoring

Forest Cover Loss 2006-2010

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Legend   0-100%

Forest Cover Loss

Grayscale
Landsat Composite

500 Km

Forest cover loss was quantified for the period 2006 to 2010 using WELD inputs. A supervised classification tree algorithm was used to map per pixel probability of forest cover loss, defined as any stand-replacement disturbance at Landsat pixel scale.

- The principal driver of forest cover loss is logging, evident in the southeast, northwest and upper Midwest of the country.
- Fire is a secondary driver, with significant forest fires found in southern California and Montana.
- Forest cover loss due to disease, including mountain pine beetle infestation, is evident in Colorado and South Dakota.
- Storm damage is another cause of forest cover loss, and include tornado tracks not evident at the scale of this graphic.

Democratic Republic of the Congo

Landsat cloud-free composite for the 2000-2005 time interval

Area analyzed: 1.8 million km²
Total images processed: 15,692

Kisangani

Mbandaka

Goma

Kinshasa

Mbuji-Mayi

Lumbumbashi

Legend

Landsat Composite

400km

Front of forest clearing in North Kivu province within a region of persistent conflict and internally displaced populations.

150km

Lattice of trunk roads and associated agricultural clearings in Maniema and South Kivu

150km

Reference:

Reference: Potapov P.V., Turubanova S.A., Hansen M.C., Adusei B., Broich M., Altstatt A., Mane L., and Justice C.O. (2011) Quantifying forest cover loss in Democratic Republic of the Congo, 2000-2010. Remote Sensing of Environment (accepted)

Data and images: http://congo.iluci.org/carpemapper/
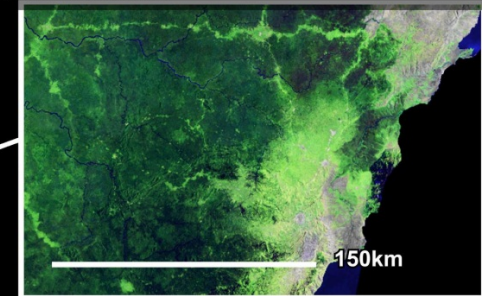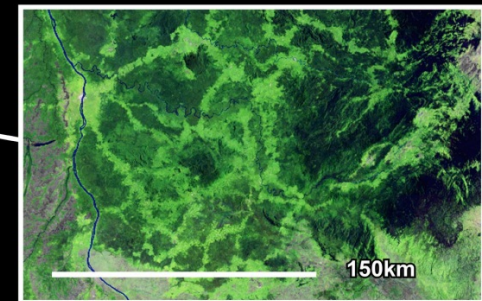
The map is a contribution to the United States Agency for International Development (USAID) Central African Regional Program for the Environment (CARPE), a Central Africa-wide initiative to monitor the forest resources of the Congo Basin in sustaining human livelihoods and key ecosystem services, including carbon sequestration and biodiversity.

An exhaustive mining of the Landsat ETM+ archive was performed to create the first cloud-free depictions of DRC at a medium spatial resolution. All Landsat imagery are processed to radiometrically normalized reflectance values and subsequently used to produce time-sequential image composites. Supervised learning algorithms were then applied to the time-series data sets to quantify both forest cover extent and loss.

This map is the first result of the Forêts d'Afrique Centrale Évaluées par Télédétection (FACET) initiative, a CARPE-supported collaboration between the Observatoire Satellital des Forêts d'Afrique Centrale (OSFAC), the University of Maryland and South Dakota State University.

Methodological development was also supported by NASA's Land Use Land Cover Change Program.
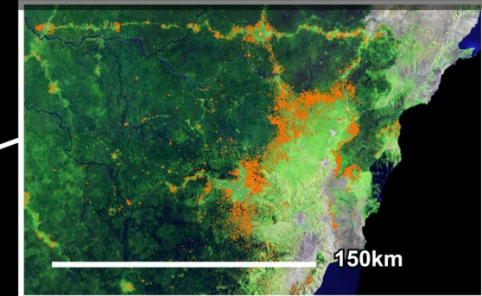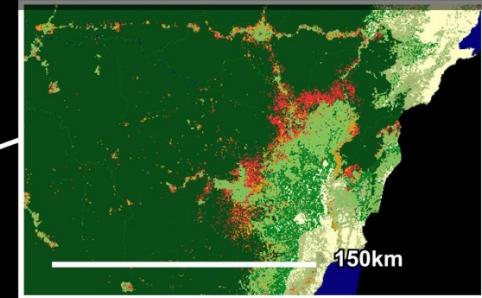
Democratic Republic of the Congo

Forest Cover Loss 2000-2005

Area analyzed: 1.8 million km²
Total images processed: 15,692

Kisangani

Mbandaka

Goma

Kinshasa

Mbuji-Mayi

Lumbumbashi

400km

Front of forest clearing in North Kivu province within a region of persistent conflict and internally displaced populations.

150km

Lattice of trunk roads and associated agricultural clearings in Maniema and South Kivu


150km

Reference:

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Data and images: http://congo.iluci.org/carpemapper/

Legend

Landsat Composite
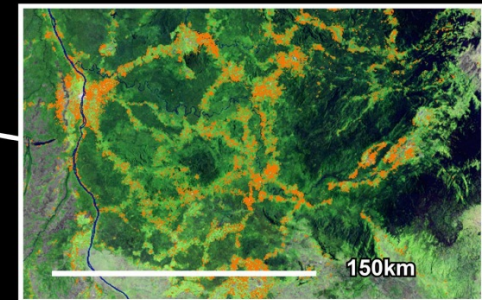
Forest Cover Loss 2000-2005

Democratic Republic of the Congo

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Data and images: http://congo.iluci.org/carpemapper/

Legend

Landsat Composite

Forest Cover Loss 2005-2010

400km

Democratic Republic of the Congo

Forest Cover Type and Forest Cover Loss 2000-2010

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150km

Lattice of trunk roads and associated agricultural clearings in Maniema and South Kivu

150km

Kisangani

Mbandaka

Goma

Kinshasa

Mbuji-Mayi

Lumbumbashi

400km

Legend

- **Primary Forest**
- **Secondary Forest**
- **Woodland**
- **Forest Cover Loss 2000-2005**
- **Forest Cover Loss 2005-2010**
- **Non-forest**
- **Water**

Reference:

Reference: Potapov P.V., Turubanova S.A., Hansen M.C., Adusei B., Broich M., Altstatt A., Mane L., and Justice C.O. (2011) Quantifying forest cover loss in Democratic Republic of the Congo, 2000-2010. Remote Sensing of Environment (accepted)

Data and images: http://congo.iluci.org/carpemapper/
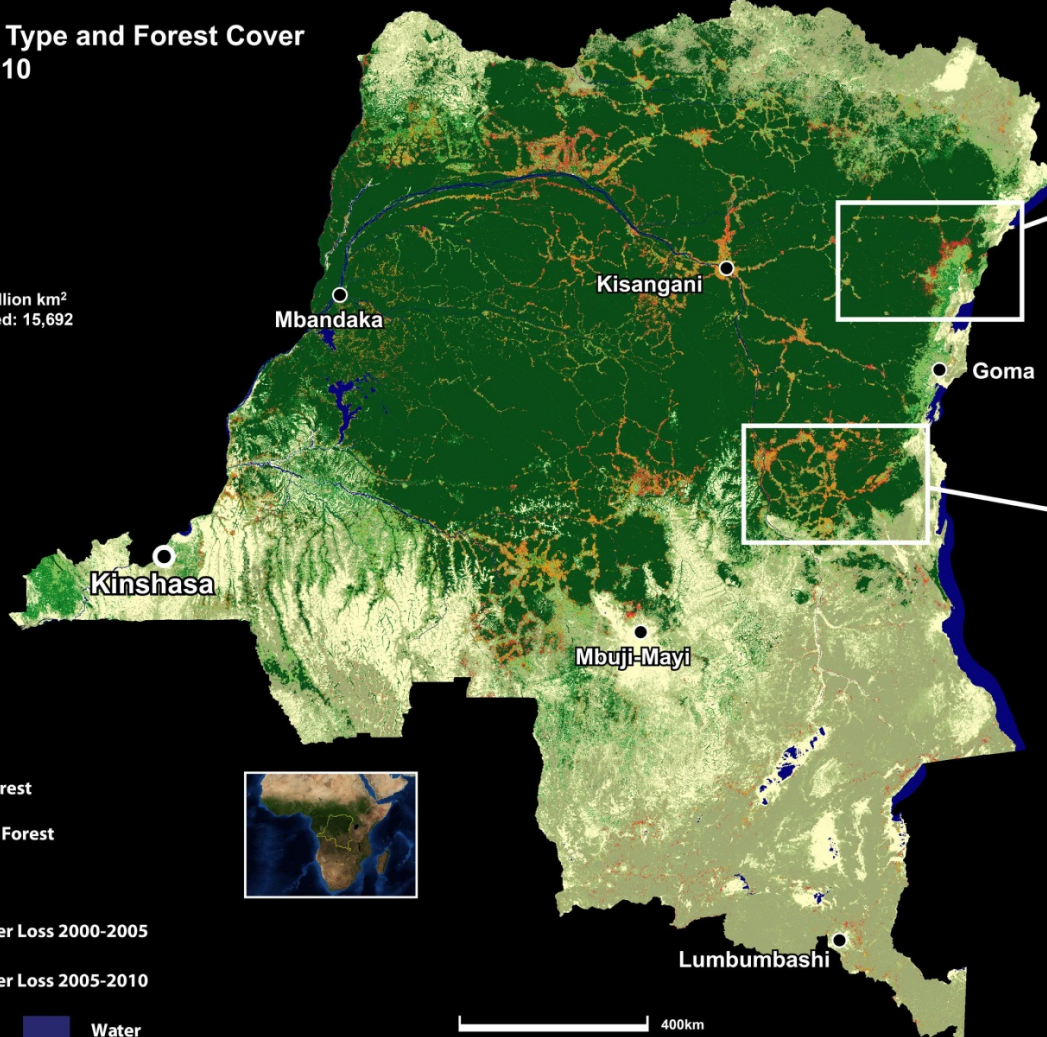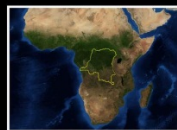
- The national year 2000 forest cover was estimated to be 1.59 million km2, with gross forest cover loss for the last decade totaling 2.3% of forest area.

- Forest cover loss increased by 14% between the 2000-2005 to 2005-2010 intervals, with the greatest increase occurring within primary humid tropical forests.
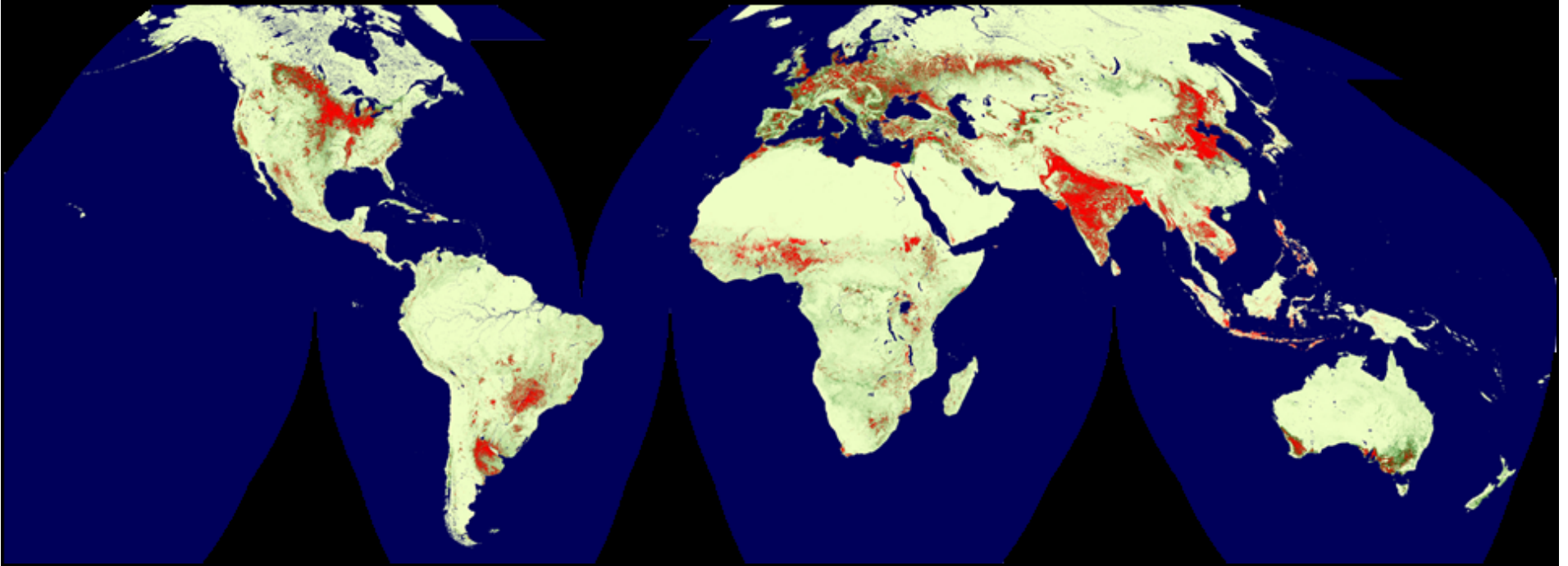
- Gross forest cover loss within protected areas increased by 64% between the two intervals.

- Results illustrate an accelerating rate of forest cover loss during the past 10 years.

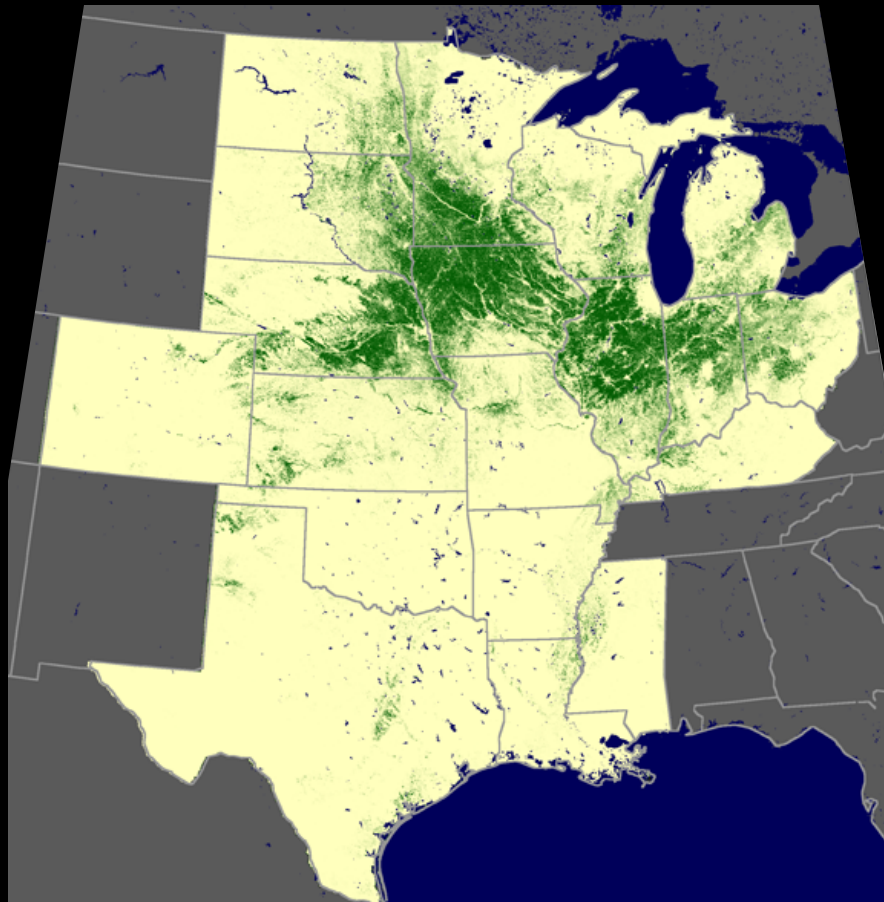NASA   USGS science for a changing world   CARPE   UNIVERSITY OF MARYLAND   SDSU
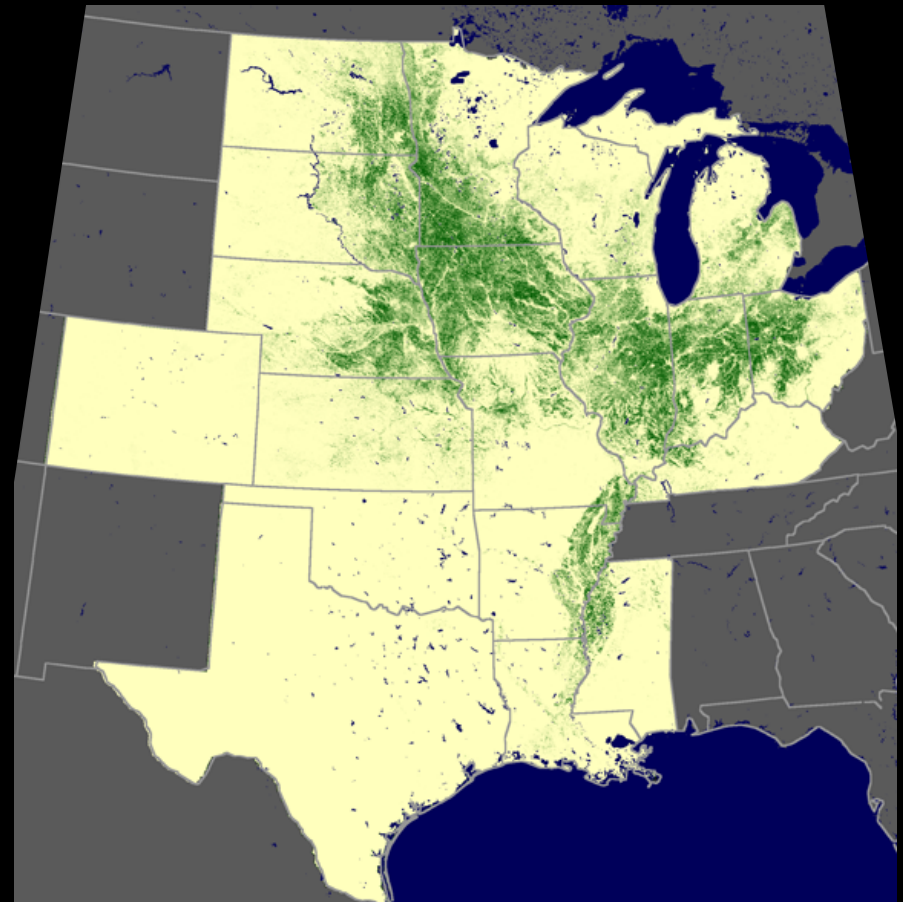
Global Cropland Extent

MODIS multi-year characterization of cropland probability where red matches per country USDA Foreign Agricultural Service reported cropland area

Crop type monitoring

100
0
Percent corn cover 2008
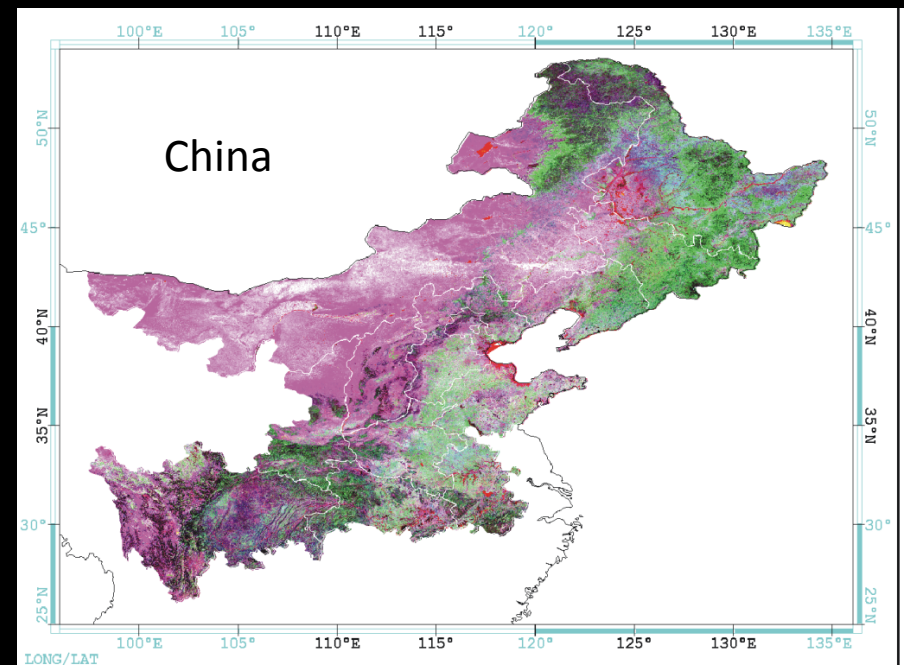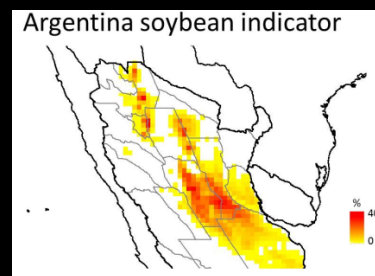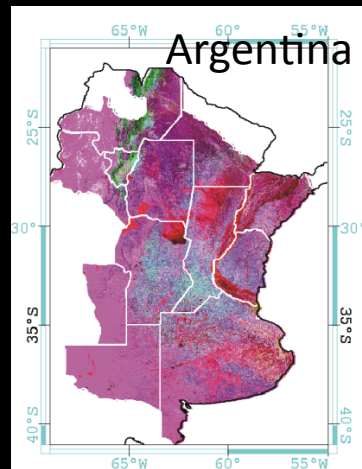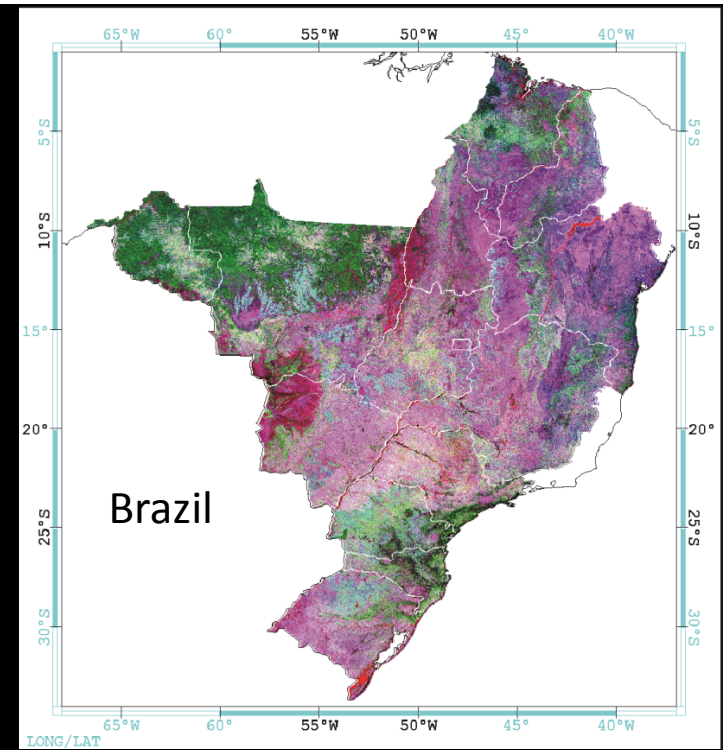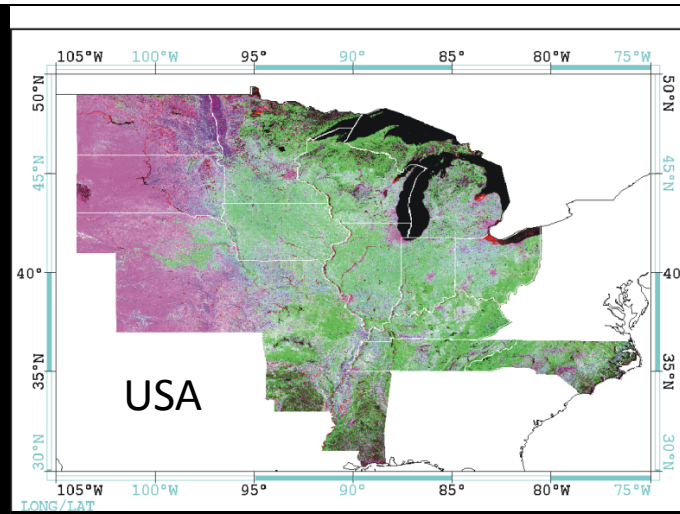
100
0
Percent soybean cover 2008

Turn-key crop type indicator maps derived using growing season MODIS time-series metrics
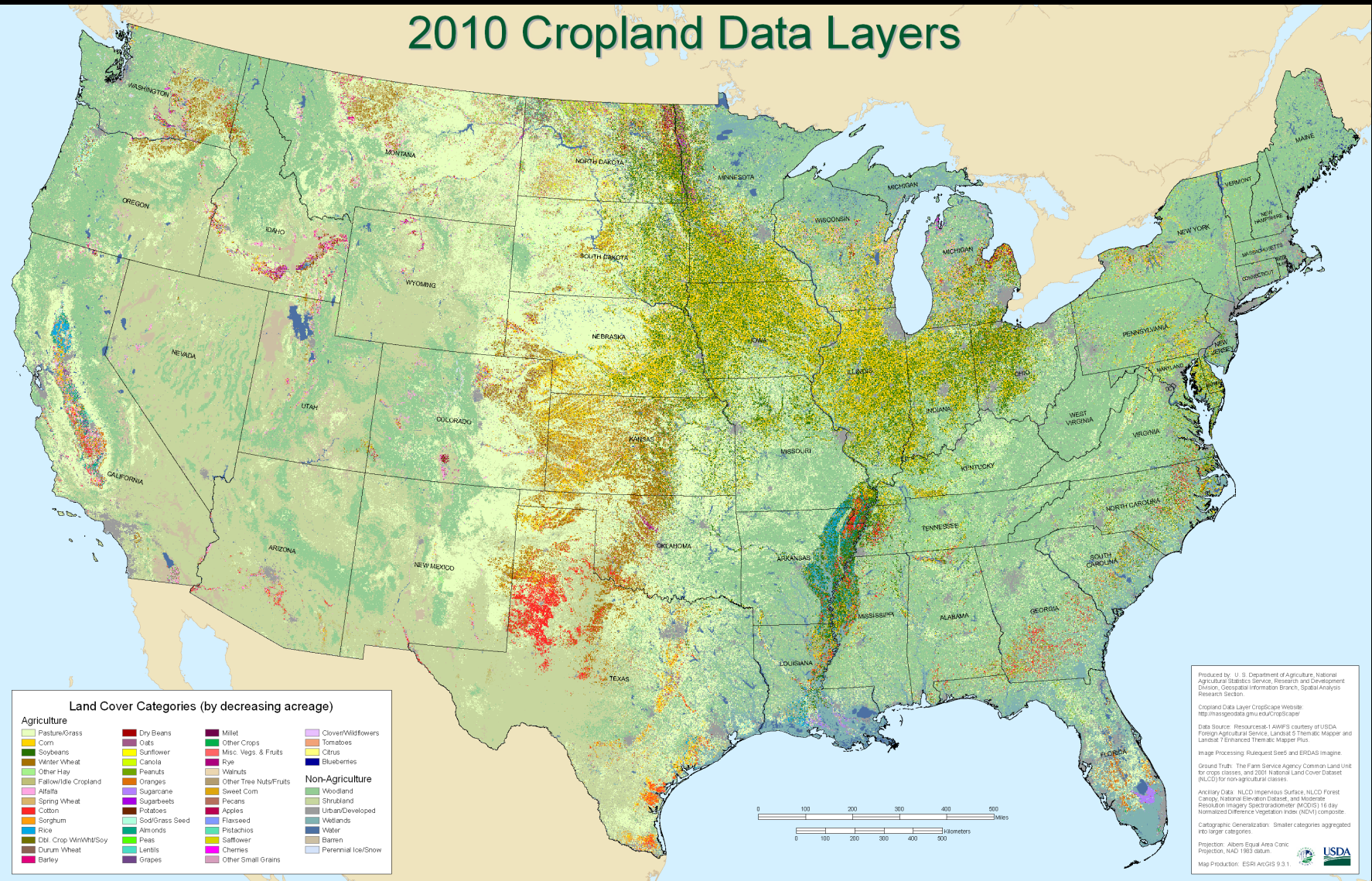
Global soybean area estimation

The top four soybean production countries, totaling nearly 90% of global soybean production include: top left, United States; top right, Brazil; lower left, Argentina; lower right, China. MODIS crop type (soybean) indicator maps are used to stratify and sample Landsat data for cultivated area estimation.

For each country, the administrative subset shown accounts for over 90% of national soybean acreage. Images, with a globally applied enhancement, are from MODIS median 9-year growing season metrics for red=visible red, green=near-infrared, and blue=shortwave infrared (band 7). An example turn-key MODIS soybean indicator product is shown for Argentina – here as a sampling frame for analysis of Landsat sample blocks.

USA

Brazil

Argentina

China

Argentina soybean indicator

2010 Cropland Data Layers

Land Cover Categories (by decreasing acreage)

Agriculture

Pasture/Grass	Dry Beans	Millet
Corn	Oats	Other Crops
Soybeans	Sunflower	Misc. Vegs. & Fruits
Winter Wheat	Canola	Rye
Other Hay	Peanuts	Walnuts
Fallow/Idle Cropland	Oranges	Other Tree Nuts/Fruits
Alfalfa	Sugarcane	Sweet Corn
Spring Wheat	Sugarbeets	Pecans
Cotton	Potatoes	Apples
Sorghum	Sod/Grass Seed	Safflower
Rice	Almonds	Pistachios
Dbl. Crop WinWht/Soy	Peas	Flaxseed
Durum Wheat	Lentils	Cherries
Barley	Grapes	Other Small Grains

Clover/Wildflowers
Tomatoes
Citrus
Blueberries

Non-Agriculture

Woodland
Shrubland
Urban/Developed
Wetlands
Water
Barren
Perennial Ice/Snow

USDA

United States Department of Agriculture

National Agricultural Statistics Service
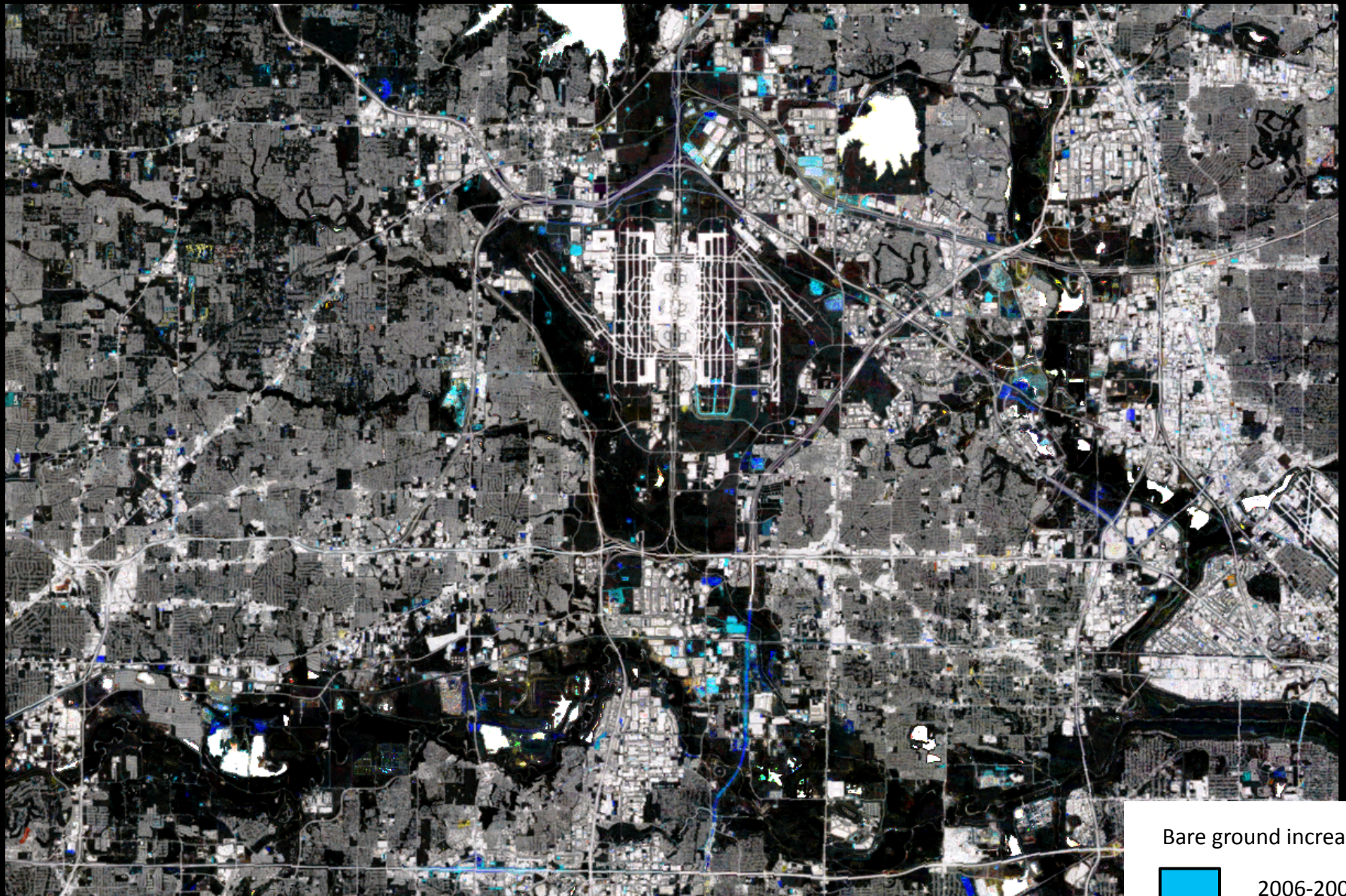
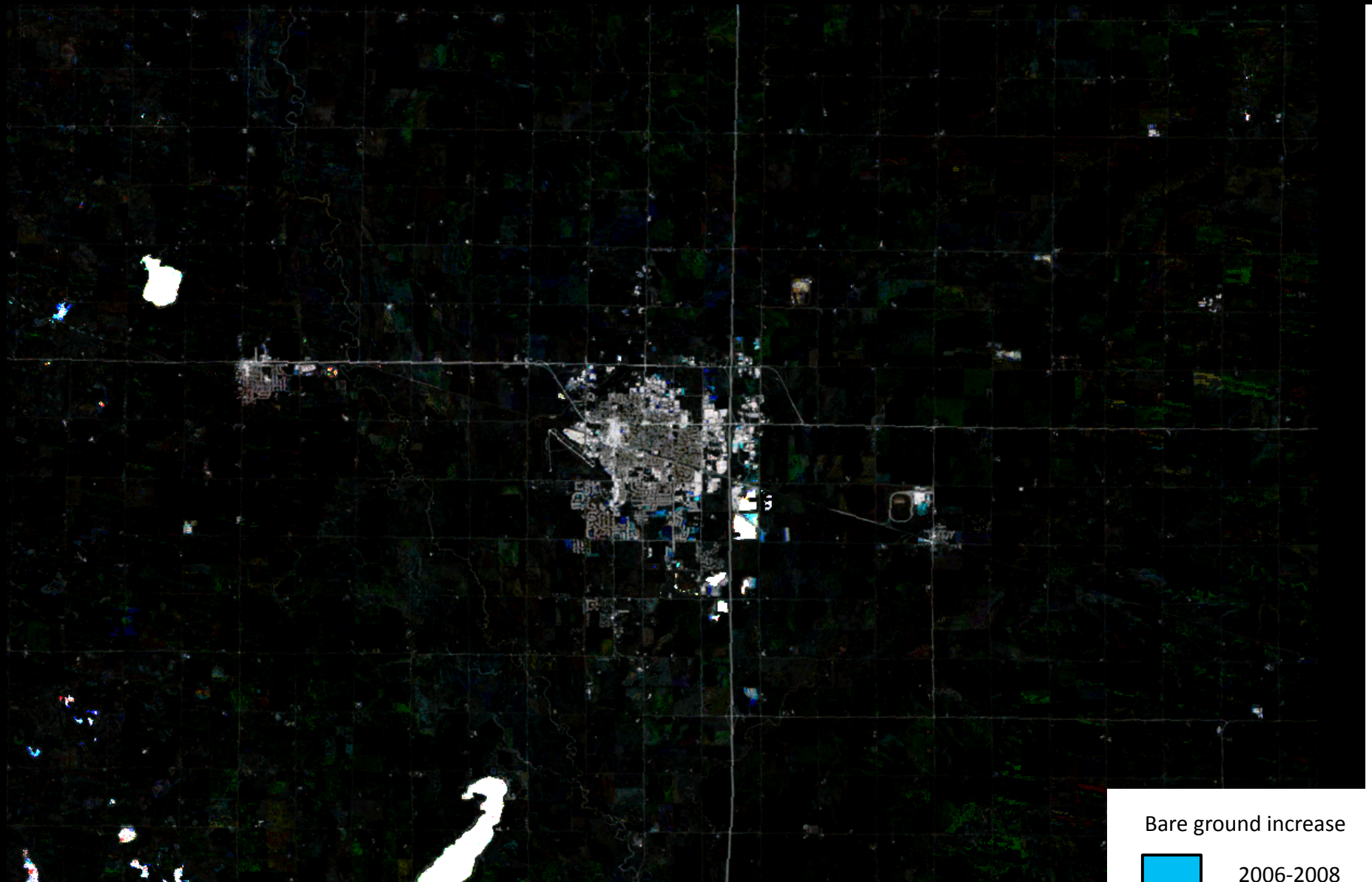**A decade of mapping the nation's croplands**

2002

corn

soybean

Urbanization

Dallas-Fort Worth, TX

Bare ground increase

2006-2008

2008-2010

Urbanization

Brookings, SD

Bare ground increase

2006-2008

2008-2010